CLAIMS

I CLAIM:

1. A method for identifying shallow subsurface drilling hazards, such as karsts, voids, unconsolidated discontinuities and partial collapses located below the earth's surface utilizing petroleum exploration seismic survey data prepared for a specified portion of a geological formation containing existing wells, the method comprising the steps of:

a. providing the original seismic data that includes reflection and refraction wave data collected for the specified portion of the geological formation;

b. filtering the seismic data to remove or mute the reflection wave data;

c. gathering and retaining the refraction wave data;

d. filtering the seismic refraction wave data by filter means selected from the group consisting of time FK, KL, data driven, and combinations thereof;

e. time-shifting and correcting the filtered data for linear move out (LMO);

f. separating each refraction wave and computing statics selected from datum statics, elevation statics and combinations of both;

g. computing residual statics for each refractor wave to provide refraction mini-volumes;

h. binning and stacking the refraction mini-volumes obtained in step (g);

i. loading the data from step (h) into a three-dimensional

visualization computer program and operating the program to provide visual displays;

j. generating a semblance cube for each refractor wave mini-cube volume;

k. flattening the time image of each of the refractor wave and semblance mini-volumes;

l. displaying the time-slice domain visually;

m. comparing the mini-volumes visual display from step (k) with historical experiential information derived from actual drilling operations of the existing wells in the geological formation; and

n. based on the comparison of data and information in step (m), identifying the location, size and relative severity of any drilling hazards in the specified portion of the formation.

2. The method of claim 1 which includes the further step following step (k) of processing and displaying the data for analysis on the X/Y-space using inlines and cross-lines.

3. The method of claim 1, wherein the computation of datum or elevation statics is completed before the separation of each refractor wave, and residual statics are computed and applied to each refractor mini-volume.

4. The method of claim 1, wherein the seismic refraction data is filtered in step (d) by a method selected on the basis of the refracted wave data.

5. The method of claim 1, wherein the visual displays are printed for comparison.

6. The method of claim 1 which further includes:

o. siting new wells for drilling in areas that are displaced from

any drilling hazards identified in step (n).

7. The method of claim 1 which further includes the steps of:

plotting the location of proposed wells in the same visualization program employed in step (i);

computing and storing refractor amplitude and frequency responses; and

computing depth and/or time correlations with the original reflection data from step (a).

8. The method of claim 1 in which the analysis is performed for drilling hazards located at about less than four thousand feet below the earth's surface.

9. The method of claim 8, wherein the depth is determined by the design of the original seismic acquisition survey and the maximum recorded offset ranges.

10. A method of processing and displaying hydrocarbon exploration seismic data prepared for a specified portion of a geological formation in order to identify the location of shallow subsurface drilling hazards, the method comprising the steps of:

a. analyzing refracted waves over a processing block;

b. selecting offset ranges and refracted wave velocities;

c. identifying spatial changes;

d. spatially correcting for refractor linear moveout;

e. applying datum statics;

f. applying surface-consistent residual statics;

g. applying filtering analysis;

h. separating refractors to separate datasets using offset ranges;

i. applying filtering;

j. applying surface-consistent statics to each dataset;

k. binning each dataset separately to CMP and stack;

l. outputting SEGY;

m. loading SEGY outputs into a three-dimensionaloftware visualization program;

n. performing quality control analysis and corrections on refractor cubes utilizing program procedures;

o. generating semblance cubes for each dataset;

p. loading pre-existing well -location coordinates or anticipated well bore locations into the program of step (m);

q. calibrating each well location against any seismic data that is available;

r. analyzing each well bore path through each refractor dataset to identify only drop-outs associated with karsts;

s. analyzing the semblance cubes against amplitude volumes for consistency; and

t. optionally flattening the refractor surfaces for time-slice analyses.

11. A computer-based system for identifying shallow subsurface drilling hazards, such as karsts, voids, unconsolidated discontinuities and partial collapses located below the earth's surface utilizing petroleum exploration seismic survey data prepared for a specified portion of a geological formation containing existing wells, the system comprising:

an output device; and

a processor including:

a. means for receiving the original seismic data collected for the specified portion of the geological formation;

b. first filter means for filtering the seismic data to remove or mute the reflection wave data;

c. means for gathering and retaining the refraction wave data;

d. second filter means for filtering the seismic refraction wave data by filter means selected from the group consisting of time FK, KL, data driven, and combinations thereof;

e. means for time-shifting and correcting the filtered data for linear move out (LMO);

f. means for separating each refraction wave and computing statics selected from datum statics, elevation status and combinations of both;

g. means for computing residual statics for each refractor wave to provide refraction mini-volumes;

h. means for binning and stacking the refraction mini-volumes obtained by the computing means;

i. means for loading the binned and stacked data into a three-dimensional visualization computer program and operating the program to provide visual displays at the output device;

j. means for generating a semblance cube for each refractor wave mini-cube volume;

k. means for flattening the time image of each refractor wave and semblance mini-volumes;

l. means for outputting to the output device time-slice domain data to be visualized;

m. means for comparing the mini-volume visual displays from the flattening means with historical experiential information derived from actual drilling operations of the existing wells in the geological formation; and

n. means for identifying the location, size and relative severity of any drilling hazards in the specified portion of the formation.

12. The system of claim 11, further comprising:

means for processing and displaying the data for analysis on the X/Y-space using inlines and cross-lines.

13. The system of claim 11, wherein the processor completes the computation of datum or elevation statics before the separation of each refractor wave, and wherein the processor computes and applies residual statics to each refractor mini-volume.

14. The system of claim 11, wherein the seismic refraction data is filtered by the first filtering means on the basis of the refracted wave data.

15. The system of claim 11, wherein the output device includes a printer for printing the visual displays for comparison.

16. The system of claim 11 which further includes:

o. means for receiving siting data for siting new wells for drilling in areas that are displaced from any drilling hazards identified by the identifying means.

17. The system of claim 11 which further comprises:

means for plotting the location of proposed wells in the same visualization program;

means for computing and storing refractor amplitude and frequency responses; and

means for computing depth and/or time correlations with the original reflection data.

18. The system of claim 11 in which the processor includes signal processing means for performing an analysis for drilling hazards located at about less than four thousand feet below the earth's surface.

19. The system of claim 18, wherein the processor determines a depth on the basis of the design of the original seismic acquisition survey and the maximum recorded offset ranges.

20. The system of claim 11, wherein the output device includes:

a display for displaying a three-dimensional representation of the processed seismic data from the three-dimensional visualization computer program.